Climate risk, optimal investment and adaptation to climate change: an analysis of the temporal and spatial dimensions of the catastrophe bond market

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Abstract

This paper discusses the relationship between the risk of climate change occurring, optimal investment, and efficient adaptation to climate change. Different forms of adaptation are classfied, and the importance of private adaptation that occurs in advance of climate change is discussed. A conceptual framework is developed that distinguishes climate risk - the risk that the climate changes - from weather risk - the risk that a certain weather event occurs. It is argued that failing to incorporate this risk into investment decisions will lead to inefficient adaptation. Instruments capable of transferring this risk are identified. A time series of catastrophe bonds, one such instrument, is studied for evidence that more or less climate risk is traded in the economy. The evidence indicates that there is very little market for climate risk; the implications of this and possible policy responses are discussed.

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1 Introduction

In the wide literature on the interaction between the climate and the economy, one open-ended question is the degree to which actors in the economy will shift their activity in light of changes to the climate, such that in any given climatic state, actors are engaging in the most profitable possible activity. While there has been much scholarly debate over the amount by which economic activity will change in response to climate change, there has been very little investigation into changes in behavior *in advance* of changing conditions. Because investments persist into time, the quality of investments made today will affect how efficient economic activity will be in the future.

In order to estimate how efficiently the economy will adapt to climate change, we must therefore understand the impact that future climate change has on current investment decisions. If it is the case that investors are naïve (and the climate does indeed change), then we might conclude that at least some economic activity in the future will be sub-optimal, as capital with a long-enough lifespan will persist into a time in which the climate is no longer suitable for it, or, capital will have to be replaced prematurely. If, on the other hand, investors are aware of the ways in which the climate may change, and the ways that this might impact their investments, some percentage of these sub-optimal investments may be avoided.

While it may not yet be possible to evaluate investment performance with respect to climate change directly, it is possible to make inferences about investment behavior by looking at inputs into investment decisions. The question engaged in this paper is therefore not how well investments *actually* perform with respect to the climate, but whether or not investors consider "the entire climatic future of their investment" (Fankhauser et al., 1999, 71). There are conceivably a few ways this consideration could be made: investors could perform their own individual evaluation of the potential climatic impact on each investment; governments could restrict or promote investments through regulation; or, if markets existed in which the risk of climate change were traded, the prices in this market could provide this signal to investors. It is this third possibility this paper will explore.

Weather is inherently non-deterministic and potentially disruptive to many forms of economic activity; it is no surprise that there are well-developed insurance markets for weather-related risks. The climate - the set of parameters whose statistical distributions are behind the behavior of the weather - is not directly observable, so it is less clear that there are, or even could be, markets that transfer the risk of the climate changing. It is argued here that the weather and climate, and their associate risks, can be thought of as end-points on a continuum over time, with weather "becoming" climate over an increasing number of observations, and that climate risk has implications for efficient adaptation to climate change. It is then argued that only certain types of transactions are capable of transferring these risks, as they are large, undiversifiable risks. This set of instruments only includes one form in wide use today: catastrophe bonds. Other transaction types are either incapable of transferring these risks or form a very small market.

The catastrophe bond market is then examined for evidence that it has, over time, evolved to transfer more or less climate risk. Focus is given to two parameters that are indicative of the level of climate risk coverage in the market: the extent to which the transaction covers climate, and not weather risks (the "depth" of coverage), and the location of the risks under coverage (the "breadth" of coverage). These parameters are catalogued for 190 catastrophe bond transactions that range over time from 1995, the year of the first transaction in the data set, to current-day.

If transactions in this market were to absorb more climate risk (by looking further into the future) over time, we would conclude that the market became "deeper" and, correspondingly, covered climate risk to a greater extent, and vice versa. Similarly, if the market evolved to cover climate dependent risks over a greater spatial extent, we would conclude the market had become "broader", and vice versa. The data, however, indicate the market has *not* moved to become deeper and broader, but has instead remained extremely narrow and relatively shallow over its lifetime. While the average depth of the market has barely changed in the 15 years of catastrophe bond transactions, it is found that the market has converged to cover a specific amount of time into the future - 3 years - and that this market may have become "locked-in" to this value.

In section 2 the academic literature relevant to this investigation is discussed. In section 3 a framework for understanding the distinction between climate and weather risk, and how this risk could be traded, is developed. In section 4 the data and methodology are described, and in section 5 the results of the analysis are presented. The implications of these results are discussed in section 6. Section 7 concludes.

2 Literature Review

There are two spheres of academic research relevant to this study: the investigation of optimal climate policy, especially with regard to the role of adaptation, and the relationship between insurance and climate change. The relevant literature from each sphere will be discussed in turn below.

2.1 Adaptation to Climate Change

The question of how well economic activity will shift in response to climate change is, in many ways, similar to one that has been explored in the literature on the agricultural impacts of climate change. Early studies of the effect of climate change on agriculture, such as Decker et al. (1986), Smit et al. (1988), Adams et al. (1990) and Rosenzweig & Parry (1994) used a so-called "production function" approach to model the impact of climate change. According to this method, climatic variables enter into the production function of the goods being produced, and as they change, so does the level of the output - but the type of output is assumed to stay the same. The "Ricardian" approach, however, developed in Mendelsohn et al. (1994) and later utilized in a number of studies (for example, see Mendelsohn & Dinar, 1999, Seo et al., 2005, Seo & Mendelsohn, 2007, Dinar et al., 2007, and Seo & Mendelsohn, 2008), assumes that at any given point in time, farmers will harvest crops that are optimal for the current climate. This sets up a spectrum between two ideal types of economic behavior: the "dumb farmer" who never adapts to changes in the climate, and the "omniscient farmer" who always behaves optimally. Not surprisingly, predictions vary considerably depending on which assumption is made.

More broadly, adaptation, or the "changes that individuals, firms or governments make to reduce the damages (or increase the benefits) from climate change" (Mendelsohn, 2006, 203-4), has received increasing attention in the study of optimal climate policy. For one, it has long been clear that even in the case of the most aggressive mitigation, there will still be enough greenhouse gas (GHG) emissions to result in climate change, so adaptation will be necessary regardless of any other response to climate change. Second, it has been shown that adaptation and mitigation are substitutes, not complements, in climate policy (Tol, 2005; Ingham et al., 2007). That is, the more resources that are spent mitigating, the lower the optimal level of resources spent adapting, and vice versa. Thus, there is a substantive tradeoff in choosing between adaptation and mitigation.

There are many possible forms of adaptation and substantial attention has been focused on exploring their respective roles. Smit et al. (1999) and Smit et al. (2000), for example, propose distinguishing adaptation activity on the basis of three attributes: when the adaptation occurs, the agent carrying out the adaptation, and the mechanism by which it occurs. Two related distinctions concern the level of foresight and the degree of cooperation required. Adaptation dependent on decisions made in advance of changing conditions is "anticipatory" while adaptation that can take place simultaneously with changing conditions is "reactive". Measures that are carried out through a central authority are "planned" whereas those that are undertaken by individuals in their own interest are "autonomous". These distinctions and their relevance to optimal climate policy are further explored in Klein (2003), Tol et al. (1998), Mendelsohn (2006) and Fankhauser et al. (1999). This paper, because it examines private investment undertaken in advance of climate change, is particularly concerned the role of with autonomous anticipatory adaptation. Other distinctions, such as spatial extent (local vs. regional) and the independence (cumulative vs. stand-alone) of the adaptation activity are discussed in Adger et al. (2005), Bosello et al. (2009) and Smit et al. (1999).

In models of climate-economy interactions, the assumptions made about the efficiency of adaptation determine, to a large degree, the projected severity of impacts across all sectors (Tol et al., 1998), just as in the literature on agricultural impacts alone. It is unfortunate, then, that analyses of optimal climate policy have been slow to explicitly incorporate adaptation. Until very recently, only one of the integrated assessment models (IAMs) that are used to numerically sift through the many causes and effects of climate change to arrive at optimal policy had included adaptation as a policy variable, the Policy Analysis for the Greenhouse Effect (PAGE), but even then adaptation was included only in the form of separate "scenarios", and not as a continuous choice that could be optimized (de Bruin et al., 2009). Recent papers, such as de Bruin et al. (2009) and Bosello et al. (2009) have begun to fill this hole in the literature, but only Bosello et al. (2009) has gone so far as to calculate the optimal shares of different *types* of adaptation. For a recent discussion on the state of adaptation in the IAM literature, see Patt et al. (2010).

There is little agreement in the literature regarding the respective roles of different classes of adaptation. Some authors have highlighted the limited ability of private actors to make efficient adaptations due to limited information or resources, and have stressed the need for anticipatory planning and action by governments (Tol et al., 1998 and Fankhauser et al., 1999). Others, such as Yohe et al. (1996), Mendelsohn et al. (1996) and Mendelsohn (2000) have argued that the incentives for private actors to make adaptations along with the low cost of replacing capital over the long-run will make anticipatory adaptation mostly unnecessary. Mendelsohn (2000, 2006) in particular argues that except in the case of public or jointly-held assets and other rare exceptions that anticipatory adaptation is unnecessary to achieve efficient adaptation.

Unfortunately, this reasoning relies on some combination of 1) capital life-spans being shorter than the time-horizon of climate change, 2) climate change happening gradually and far in the future and 3) the fact that, over the long run, the costs of replacing capital are low. The first of the above, arguably, has the effect of allowing investors to make efficient *reactive* (that is, after changes have already occured) investment decisions; the second implies a reduced impact on the present value of investments (Bennett & Mendelsohn, 1997) and, with the third, the reasoning is that "[i]n the long run, all capital is replaced" (Mendelsohn, 2000, 588), so capital can be efficiently replaced simply when it would have been in any case. The first two arguments neglect the possibility of climate change happening abruptly and well within the investment horizon of some sectors, which recent climate research indicates is a real hazard (Milly et al., 2002; Alley et al., 2003; Steffensen et al., 2008) and that changes to ecosystems are already happening (Walther et al., 2002). The third argument glosses over the implication that society may, in this case, be saddled with under-performing capital for material amounts of time. In addition, the above arguments do not consider the fact that capital investment may have cumulative characteristics - real estate investment may spur people and industries to move to a new area, for instance - and other temporal and spatial spillover effects of investment decisions (Adger et al., 2005; Bosello et al., 2009). Furthermore, in the only effort to date to explicitly model the optimal contribution of different forms of adaptation, Bosello et al. (2009) have found that until nearly the end of this century the bulk of adaptation should be anticipatory, because "[w]hen [the cost] is sufficiently low, it is worth preparing to face future damages. When it becomes high and increasing, larger amounts of resources need to be invested in ... what cannot be accommodated *ex ante*" (22).

There has been relatively little investigation into optimal changes to the invested capital stock in a changing climate, but Fankhauser et al. (1999) find that assets must either be replaced more frequently, and thus have shorter a shorter overall life-span, perform better under a wider range of climatic conditions, or both. They argue that as uncertainty surrounding the future state of the climate increases, investors may demand a higher return for climate-sensitive projects, or shift their capital to investments that are more resilient to changes in the climate. It is crucial here, however, that investors either have good working knowledge about future possible states of the climate and its impact on their investments or have some market signal that encapsulates that information. Insurance, as a hedge against uncertain weather and as an input into investment decisions, is a natural candidate to provide this market signal.

2.2 Climate Change and Insurance

Given that climate change is typically defined as a change in the statistical distribution of climatic parameters (IPCC, 2007), including the frequency and severity of extreme events, it should be no surprise that the connection between climate change and insurance has received a great deal of attention from scholars. Studies in this area can roughly be categorized into 1) explorations of mitigation as a form of insurance, 2) insurance as compensatory adaptation, 3) the quasi-regulatory effect that the insurance industry can have on mitigative or adaptive measures, and 4) the impact that climate change has or will have on the insurance industry itself.

Some scholars have framed the debate regarding how much mitigation is optimal as a question, in effect, of how much "insurance" society should buy against an uncertain climatic future; see, for example Nordhaus (1991), Manne & Richels

(1991), Nordhaus (1994), and Weitzman (2007). By mitigating, we limit the set of future possible climatic states and, in particular, thin out the "fat tail" of catastrophic events. Other scholars have considered using insurance-like mechanisms to cap the losses of vulnerable countries; see, for example, Bals et al. (2006), Hoff et al. (2005), and Linnerooth-Bayer & Mechler (2006). These investigations into the relationship between climate change and insurance are not relevant here. The first formulation because it is a particularly broad formulation of "insurance", which holds only passing relevance to the industry; the second because it concerns mechanisms for carrying out *ex post* compensation for climate change, rather than *ex ante* adaptation.

Others, such as Leggett (1993a,b, 1994), Mills (2007, 2005), and Hecht (2008), have explored the role that the insurance industry can play as a quasi-regulator, by promoting activities (such as energy efficiency (Mills, 2003)) through differentiated premia that will lower the insurers' exposure to climate-related risks. These analyses are ultimately unconvincing because they suffer the same collective action problem that troubles the climate change dilemma elsewhere; these measures only work if enough firms engage in them. While it might make sense for the insurance *industry* to differentiate premia depending on the climatic impact of the entity insured, it would rarely make sense for an *individual* insurer to do so (Tol et al., 1998).

Another stream of literature debated over the attribution of rising economic costs due to severe weather events. See, for example, Emanuel (2005), and Mann & Emanuel (2006); and Pielke & Landsea (1998), Changnon et al. (2000), and Pielke et al. (2005). Elsewhere, the effect of these events on the insurance industry is considered (Changnon et al., 1997). While this question is far from settled, the debate itself acknowledges that damages are rising, which supports the fundamental conceit of this paper: people moving into or investing in vulnerable regions expose themselves to the risk that the climate changes, and that their investments will be worth less if the climate changes than they would be if the climate stayed constant. The present value of this effect is shown in Tucker (1997), who examines the effect of increased climatic variability on insured assets using the Black-Scholes pricing model, and finds that this justifies higher insurance premiums. If future changes in the climate are not considered, then climate-sensitive investments would be encouraged beyond the optimal level, because insurance premiums would not reflect this risk.

3 Conceptual Framework

This section will develop a framework for understanding how climate risk might be exchanged, and discuss the significance of market allocation of this risk. First, it is shown that climate risk is a risk *in addition* to weather risk, and that the two are separated by the amount of time under observation. Second, it is argued that this risk would be allocated by a market in a best-case scenario. Finally, an overview of standard instruments in the wider insurance market is given, and those types capable of transferring this risk are identified.

This paper does not attempt to answer the question of whether or not climate risk is *accurately* conveyed to investors via market signals, or whether or not it makes a meaningful difference in investment decisions; it instead attempts to find evidence that there are channels to convey this risk to investors. Furthermore, because this study focuses exclusively on the insurance sector, it will necessarily not be exhaustive - there may in fact be transactions in other sectors of the economy in which climate risk is traded implicitly or explicitly. However, in an initial attempt to gauge the effect of climate risk on investment decisions, the insurance sector - whose function is to transform and allocate risk - is a worthwhile place to start.

3.1 Climate Risk

Here "climate risk" is defined and its distinction from another type of risk, which here will be called "weather risk", is presented. Earth's climate, as is well-known, is not a deterministic system. It is a stochastic system represented by an underlying probability distribution. In any given time period, one faces the risk that an observation of the distribution is unfavorable - in any given year, a massive hurricane could make landfall in Florida, for example. This is weather risk. Climate risk, on the other hand, is the risk that the climate distribution itself changes; for example, it might be the case that in five years, hurricanes are much more likely to make landfall in Florida.

Weather risk and climate risk are clearly related, but there is an important distinction between the two: weather risk concerns *draws* from an underlying distribution whereas climate risk concerns the distribution itself. Which risk is relevant depends on the amount of time under consideration. Over a short time-span, relatively few events are observed, so the risk is that one, or a few, of these events is or are unfavorable - that a hurricane will occur, for example. Over a long-enough time-span, however, the number of such events likely to occur will be determined by the underlying distribution, so the implicit risk here is not that, for example, *a* hurricane will occur, but that, over time, the distribution changes and many more occur than is predicted initially. Event risk and climate risk can then be seen as two ideal types of risk, separated by a continuum that changes over the amount of time observed, as is illustrated below in figure 1. Long-lived investments will therefore face *both* weather and climate risk: weather risk over short time horizons and climate risk in the long-term.

Figure 1: The Relationship Between Climate Risk and Weather Risk

In any transaction in which risks tied to weather-related phenomena are exchanged, the degree to which the risks are climate risks, as opposed to weather risks, will then depend on the duration of the "risk period". The risk period is the temporal specification of the transaction: the period within which risks are covered and outside of which risks are not. It is beyond the scope of this paper to determine at what point weather risk "becomes" climate risk; in any event such a determination would be mostly arbitrary. In the analysis that follows in section 5, there is no attempt made to categorize transactions into those that cover climate risk and those that do not, but instead, qualitative shifts in the duration of risk periods in weather- or climate-related transactions are detected. A shift towards longer risk periods could then be interpreted as a shift towards more climate risk coverage, and vice-versa.

Climate change is widely expected to have effects that vary significantly across space. Transactions that cover risks that are tied to a particular location will therefore be dependent upon - and convey - information relevant to that location; information regarding other regions will be less relevant to such transactions and will have a correspondingly smaller impact on their valuations.

Markets in climate risk may therefore vary in their coverage across two parameters: time and space. Ideally, from a climate-adaptation perspective, markets in climate risks would be "deep" - covering a great deal of time - and "broad" - covering many regions - but they may also be "shallow" or "narrow". In the analysis that follows in section 5, existing markets are analyzed against these parameters. This paper does not, however, attempt to discern the "market price" that investors charge in exchange for assuming a portion of climate risk.

3.2 The Importance of Climate Risk

All risks can be thought of as costs: things in the economy with a negative price. This is evidenced by the fact that firms and individuals demand compensation for holding risk. Costs, or harm, just like benefits, can be exchanged in markets and allocated to individuals and firms who receive or can produce the most value from the item.

The market for waste is a useful comparison. In a typical wealthy country, firms and individuals pay other companies to dispose of their waste. The value of the waste is less negative to the disposal firm because it is equipped to handle it. If there were no way to exchange waste, then individuals and firms would have to dispose of it themselves. This might be less efficient than a market would be, but at least in this case we could be relatively assured that actors in the economy would have or develop this fairly mundane capability.

In the case of climate risk, it cannot be assured that individuals and firms are capable of "disposing" of this risk optimally without the ability to trade it. As stated above, while there has been little scholarly exploration of this question, it is thought that this capability is quite limited (Tol et al., 1998; Fankhauser et al., 1999). To do this, individuals would have to be able to (1) have good knowledge about the possible *localized* effects of climate change (that is, those effects relevant to their investments), (2) make a determination about the effect these climate impacts would have on their investments and (3) make changes to their investments to reflect this knowledge.

As Tucker (1997) shows, this risk has a value today, and consideration of this risk would encourage certain investments over others. Some investments made today take on more climate risk than others: real estate investment in a low-lying floodplain is more exposed to perturbations in the climate than building a website, for example. If the added climate risks of investments are not considered, it is possible that the future capital stock will under-perform, and that actual autonomous anticipatory adaptation will be well short of what is possible.

3.3 Types of Risk Transfer

Whereas above the benchmarks (temporal and spatial) are detailed by which transactions are appraised in section 5, this section will detail which *types* of transactions are included. Only a few types of insurance intruments are capable of transferring climate risk, however, and of these, only the market in catastrophe bonds is mature enough to be meaningful. This section will give an overview of the wider risk transfer market, and outline the criteria that transactions must fulfill to be able to transfer climate risks.

One way to distinguish risk transfer mechanisms is by characterizing the groups that cede and accept the risk. Some transactions are "many-to-one", meaning many individuals or firms transfer their risks to one firm; others are "one-to-many", meaning one individual or firm will transfer its risks to many. For reasons discussed further in section 3.4, only transactions in which risks are transferred to a large group are capable of transferring climate risks.

3.3.1 Many-to-One Risk Transfer

This section will briefly overview the types of contracts employed in the traditional and Alternative Risk Transfer (ART) markets that function to *aggregate* risks, that is, to transfer risks from many firms or individuals to one. ART is an umbrella term for a wide variety of methods of transferring risk outside of the traditional insurance market. Charpentier (2008) divides the ART market into two categories: alternative reinsurance and financial reinsurance. A third category is added here: index insurance. Both traditional insurance/reinsurance and alternative reinsurance are "many-to-one" forms of risk transfer and are discussed below. Mechanisms in the financial reinsurance category are either "one-to-many" or "many-to-many" and are discussed in section 3.3.2

Traditional Insurance and Reinsurance

The "traditional" insurance market is perhaps familiar to most people. In this market, insurers write policies to a great number for people or firms exposed to similar risks; an auto insurer might issue policies that cover automobile accidents, for example. With a large enough pool of policies, the liability of the insurer can be carefully calibrated, and the insurer can adjust the premiums it charges accordingly.

The reinsurance market has a similar function, only at a higher level: amongst insurance companies as opposed to individuals or firms. Since insurance companies typically have a sectoral or regional focus, they are not immune to correlated events: a wildfire might destroy all of the houses in a given region, for example. Reinsurance companies aggregate this form of risk across many insurance companies with different regional and sectoral focuses.

Not every risk is insurable, however. Notwithstanding other legal and economic requirements beyond the scope of this paper, to be actuarially insurable, risks must be small relative to the insurer (so the insurer can stay solvent if it must pay out a claim), similar and able to be pooled, and have a known and quantifiable expected loss (Charpentier, 2008).

Natural disasters, such as earthquakes and hurricanes, are often uninsurable: the loss faced by certain catastrophes is simply too large to be absorbed by traditional markets, and furthermore these risks are not diversifiable with similar and independent risks (Charpentier, 2008; Tol, 1998). After Hurricane Andrew, which struck Florida in 1992, seven property insurers became insolvent (ISO, 1994). This disaster, along with the Northridge Earthquake in Southern California in 1994, spurred the development of other techniques for transferring risk outside of the traditional market.

Alternative Reinsurance

Alternative reinsurance is simply an extension of the traditional reinsurance market. Two common forms of alternative reinsurance are sidecars and industry loss warranties (ILWs). A sidecar is a special-purpose company that enters into a contract with a reinsurance company to accept a portion of the reinsurance company's premiums in exchange for being responsible for the same share of losses. As such, it opens up the business to outside investors and it allows reinsurers to access capital from other sources; it does not, however, change the fundamental nature of the business.

ILWs are reinsurance contracts that have a slightly different structure than is typical. Whereas reinsurance contracts will make payouts based on their policyholders' losses, these contracts are tied to the industry's losses as a whole, and not those of any individual company. Because of their relatively standardized nature, they allow other investors to provide reinsurance protection, but again they are not fundamentally different from traditional reinsurance.

Index Insurance

One highly-discussed form of insurance in relation to climate change is weather-index insurance, wherein subscribers (often farmers or livestock herders in developing countries) pay a premium to receive a fixed payout contingent on specific weather variables. Subscribers may receive a payout if rainfall is abnormally high or low, for example. For a detailed description of many of these schemes, see Warner et al. (2010).

Although contract details for this form of product are, in general, difficult to obtain, it seems that these policies are typically cover one season and are settled annually (Skees, 2008), indicating that the risks transferred are weather risks as opposed to climate risks. Under this scheme, some or all of the risk of a crop or livestock failure is transferred, but the risk that, over time, the region becomes unsuitable for farming or herding is not.

3.3.2 Financial Reinsurance

The financial reinsurance market encompasses two categories of instruments: catastrophe bonds and catastrophe derivatives. In both instruments, the group to whom risk is transferred is potentially large. How these types of transactions function is explained here in turn.

Catastrophe Bonds

In a catastrophe bond transaction, a large risk is transferred to a large group of investors. These instruments are complicated, and a detailed description of a typical contract is unnecessary for the purposes of this paper. Simply put, investors buy bonds that are tied to a specific event, or "trigger". If the trigger *does not* occur, the investors receive the full principal at maturity, along with interest payments over the life of the bond. If the trigger *does* occur, however, then some or all of the principal is transferred to the company that sponsored the bond. A catastrophe bond might be sponsored by a property insurer in Florida to cover the risk of a large hurricane, for example.

The most important aspects of the instrument for these purposes are that a relatively large group of investors puts their capital under the risk of an event occurring over a specific length of time - the risk period. In exchange, bondholders are compensated for their risk by the "spread" of the coupon rate over some risk-free rate, usually LIBOR or US Treasury bonds (PIMCO, 1997).

Catastrophe bonds are elaborate transactions, and typically involve one or more investment banks to structure and place the transaction, a modelling agency to perform calculations regarding the relative risk of the bond and, if needed, to determine if the bond is triggered, and a rating agency to rate the bond. Many catastrophe bonds are split into multiple tranches, with different associated risks that pay different rates of interest. There is no standard template, however: sometimes some tranches are rated whereas others are not, some catastrophe bonds are not rated at all, and many bonds are not split into separate tranches.

Catastrophe Derivatives

Derivatives are zero-sum contracts whose final payment between counterparties is determined by an underlying index; for catastrophe derivatives the index is related to a certain type of event. For example, the Chicago Mercantile Exchange uses a propriety index to measure hurricane intensity, and they list a number of contacts where the final settlement between parties (the buyer and seller of the contract) is determined by the value of the index, either for a particular hurricane or for the accumulated value over a region's hurricane season (CME, 2007). The indices upon which catastrophe derivatives are constructed are typically linked either to physical measurements (such as windspeed) or industry-wide losses due to an event.

Because catastrophe derivatives are not linked to the losses suffered by an individual firm and are transparently valued, they can be bought and sold by anyone willing to enter the market, regardless of whether or not they are exposed to the underyling risk. It is for this reason that for any given risk, the group to whom the risk is transferred is potentially large.

Catastrophe derivatives are now traded on various exchanges, but this market is relatively new. Hurricane derivatives were listed on the Chicago Mercantile Exchange and the Insurance Futures Exchange in 2007, and on Eurex in 2009 (CME, 2007; Eurex, 2009; IFEXa).

3.4 Transforming Subjective Risk into Objective Risk

One function of all insurance contracts is to transform subjective risks into objective risks. Subjective risks are those characterized by a subjective probability function; they either will or will not occur and any estimate of the likelihood of the event occurring will simply reflect a given set of assumptions . Objective risks have an objective probability function, meaning that over a large group of observations it is possible to have a very good estimate of the number of times that risk will be realized.

In the traditional insurance and reinsurance market, along with the alternative reinsurance market, small subjective risks are "objectified" by aggregation. For example, the risk of a car accident for any one driver in a given period of time is a subjective risk. An accident either will or will not occur; there may be some probability of the event occurring, but it is a subjective probability. From the perspective of an insurance company that has written the policy for this and many other drivers, the risk faced becomes objective, however. They care little about any individual policyholder; their point of reference is the portfolio as a whole. From years of observation, they know with great precision how many drivers in any given period of time are likely to get into an accident, and they charge their premiums accordingly.

It is also possible to objectify very large subjective risks. Instead of being aggregated, they are divided amongst a large group. Each riskholder will then be able to diversify their portfolio by holding slices of many different subjective risks. Any given piece of the portfolio still represents a subjective risk, as does any one policy in an insurer's portfolio; over the whole portfolio, however, the risk is objective. In the financial reinsurance market, risks are objectified in this way, either by a one-to-many transfer of risk as in the catastrophe bond market, or by a many-to-many transfer in the catastrophe derivatives market.

Index-based insurance poses a particular challenge for this analysis. For any given year, the risk held by insurers is subjective. The risk is "objectified" by repeating the transaction over a number of years. This type of contract would, in theory, be capable of transferring climate risk if it were binding over a number of years (if, for instance policyholders were forced to renew every year for a given number of years), or if it could be bought years in advance. In the first case, the transaction would function like a catastrophe bond, transferring climate risk from the insurer to policyholders (in the current mechanism, if the climate changes and insurers must raise their premium to reflect a higher expected loss, their policyholders may not renew; insurers would then be unable to spread their risk over time). In the second case, the contract would mimic a catastrophe derivative. However, it is not currently the case that these contracts are binding over a long duration; thus, they were not included in this study.

Because the risks faced as a result of climate change are, in general, large, subjective and poorly diversifiable (Tol, 1998), the traditional and alternative in-

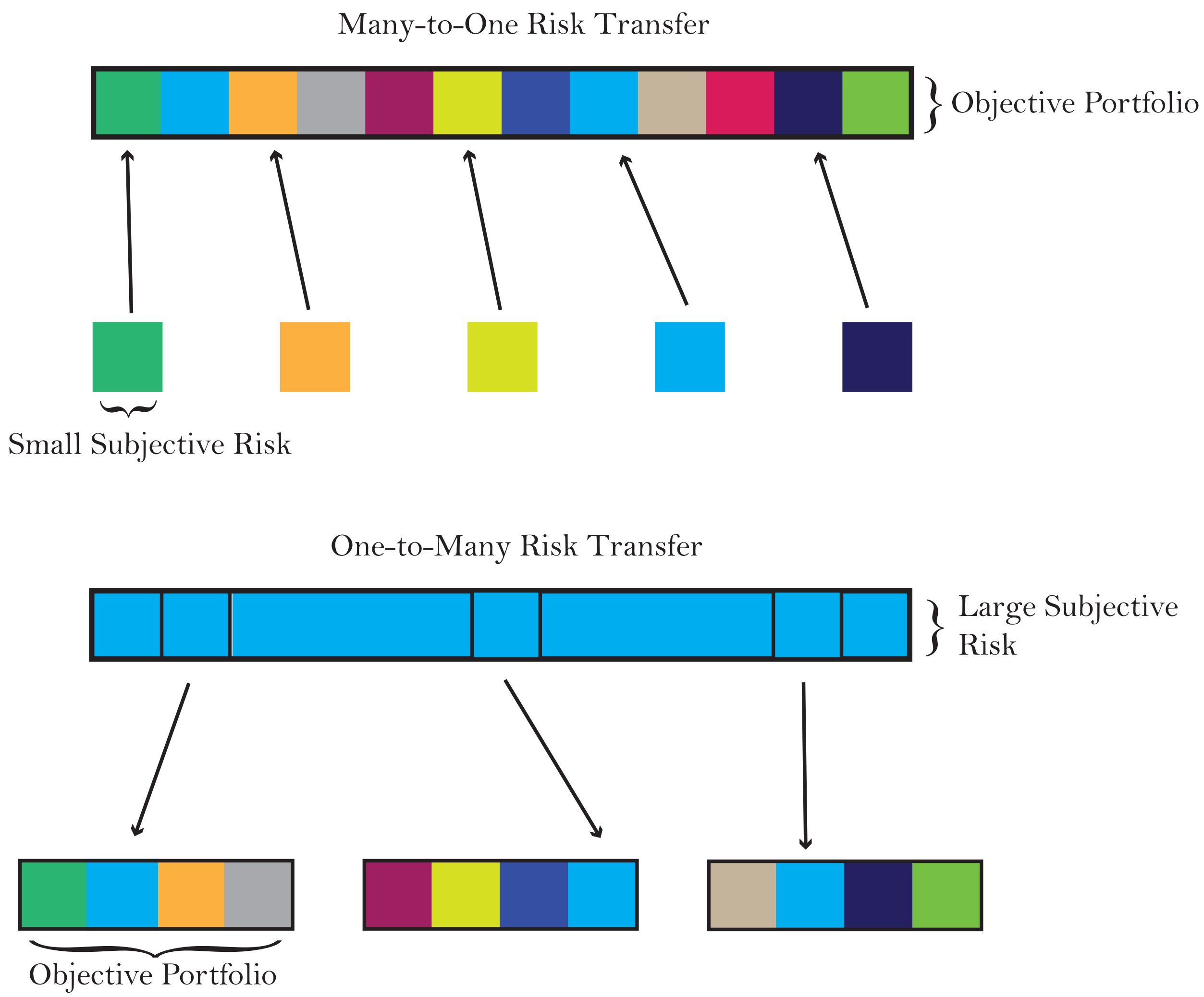

Figure 2: Different forms of risk transfer

surance/reinsurance markets are not capable of transferring climate risk. Risk transfer mechanisms in the financial reinsurance market, however, are capable of transferring such risks. It is for this reason that this paper focuses exclusively on the financial reinsurance market.

The catastrophe derivatives market is young, and there have been relatively few transactions. The first catastrophe bond transaction, on the other hand, took place in 1995, and the market has grown steadily since then. Due to the paucity of available data, catastrophe derivative transactions were not included in this study

4 Methodology

The data set includes all catastrophe bond transactions for which data are publicly available. The full list is included in the Appendix. Unless otherwise stated, data for each transaction were obtained from the Deal Directory, which is a list of transactions maintained on the website www.artemis.bm (Artemis). This list was supplemented and corroborated from a variety of sources, including trade publications, industry reports and press releases. The full list of references for the data set is included in the Appendix.

Characteristics of each transaction were coded into a handful of relevant categories: the type of risk(s) covered, their geographical location, the duration of the risk period, and the value of the transaction. Values were converted into 2010 US Dollars, using the US Federal Reserve Bank of Minneapolis's inflation calculator (US Federal Reserve), and the European Central Bank's historic exchange rates (European Central Bank). Transactions for which the risk period was unobtainable were excluded.

Transactions were split into two categories depending on the type of perils covered: "climate dependent" and "climate independent." Dependent transactions covered risks whose frequency and severity are determined by the climate: risks such as windstorms and floods, for example. Independent transactions covered risks such as earthquakes, which are not affected by the climate. If a deal (or tranch of a deal) covered a mix of independent and dependent risks, they were classed as dependent. A special case were transactions that covered "extreme mortality", which is the risk to life insurers that mortality rates increase sharply (i.e., due to a pandemic). Although the risks of vector-borne diseases are thought to change with the climate (Tol, 2001), these transactions were placed in the independent category on the supposition that the likelihood of a non-climate-related calamity causing increased mortality outweighed the chances of some climate-related development doing so.

Transactions with tranches with either different risk periods or a mix of climate dependent and independent tranches were treated as multiple transactions. The data were tested for significant changes to the mean and variance of risk-period durations. Because the statistical test used to analyze the distribution of risk-period durations (Levene's test) required discrete groups of data, transactions were grouped into arbitrary four-year periods, beginning with the years 1995 through 1998, and ending with the years 2007 through to the first transaction in July, 2010.

5 Analysis

In this section salient data from both the temporal and spatial analyses are presented in turn.

5.1 Temporal

The catastrophe bond market has grown a great deal since its inception in 1995. The average number of transactions per year has increased from 5.5 over the years 1995 through 1998 to an average of over 20 for the years 2007 through 2010. The total value of all transactions (in 2010 US dollars) has increased from an average of US$ 863 million per year over 1995-1998 to an average of US$ 4.9 billion from 2007 through July 2010.

Years	Deals/Year	Deal Volume/Year (mm 2010 USD)	% Climate Dependent
1995-1998	5.5	863.5	77
1999-2002	9	1338	61
2003-2006	14.75	2888	64
2007-2010	20.37	4930	73

Table 1: The Growth of the Catastrophe Bond Market

Some aspects of the market have remained relatively constant, however. The percentage of climate dependent deals - that is, covering perils whose frequency and severity are determined by the climate - has remained close to 70% for every four-year grouping. There has not been a significant change in the mean maturity, or even *any* change after the first four years (because catastrophe bonds are typically repaid immediately following the culmination of the risk period, the terms "risk period" and "maturity" are used interchangeably) over time. For each four-year grouping excluding the first (the years 1995-1998), the mean maturity is very close to three years. The median maturity for each these groupings was exactly 3 years. In the first four years of the market's life (1995-1998), when there were far fewer transactions, the mean maturity was 2.44 years and the median was 1.5 years.

Years	Mean Risk Period (Years)	Standard Deviation Years)
1995-1998	2.44	2.33
1999-2002	3.02	1.71
2003-2006	2.99	1.17
2007-2010	3.10	0.97
Levene's Statistic Based on Mean: 6.292**		
**Significant for $p < 0.01$		

Table 2: Changing Distribution of Risk Periods Over Time

Likewise, the difference between the average maturities of climate dependent and climate independent transactions - 2.87 and 3.22 years, respectively - was not significant.

While the mean risk period durations show little change either over time or between the types of perils covered, the *distribution* of risk periods changes significantly over both variables. The data show a considerable convergence to the three-year maturity over time. The standard deviation of risk period duration decreases steadily from 2.33 years in the years 1995 through 1998 to 0.97 years in the years 2007 through 2010. To test whether these changes are significant, Levene's test for the homogeneity of variance is applied. Levene's statistic, based on both the mean - $F(3,181) = 6.292$ - and the median - $F(3,181) = 5.052$ - were significant for $p < 0.01$, indicating that the observed changes to the distribution of risk period duration are significant.

The data show a similar effect across the type of perils covered in the transaction. The distribution of maturities for climate independent transactions has a standard deviation of 1.82 years whereas the corresponding figure for dependent transactions is 1.17 years. Levene's statistic based on both the mean and median, $F(1,183) = 6.629$ and 5.297, respectively, is significant for $p < 0.05$, which indicates

Type of Transaction	Mean Risk Period (Years)	Standard Deviation (Years)
Climate Independent	2.87	1.82
Climate Dependent	3.22	1.17
Levene's Statistic Based on Mean: 6.629*		
* Significant for p < 0.05		

Table 3: Different Distributions for Dependent and Independent Transactions

that these distributions are significantly different as well.

The evolution of catastrophe bond maturities over time can be seen in figure 3. Each row represents data for a four year period, beginning at the top with the period 1995-1998, and culminating at the bottom with the years 2007-2010. The data are categorized into climate dependent and independent transactions, and show the frequencies of different maturities within each period. One can clearly see that the three year maturity has emerged as the dominant form of transaction, especially for climate dependent transactions.

Figure 4 shows the data in a slightly different way: one can see that the markets for climate dependent and independent bonds have become more "focused" over time, but that the effect is more pronounced in dependent transactions.

5.2 Spatial

The risks covered by catastrophe bond transactions fall overwhelmingly in the United States, Europe, and Japan. There are very few transactions of any type (climate dependent or independent) that cover risks outside of these regions, and even fewer dependent transactions.

Many transactions cover more than area, and table 4 shows a breakdown of the location of risks covered by these transactions. In the table, where two different

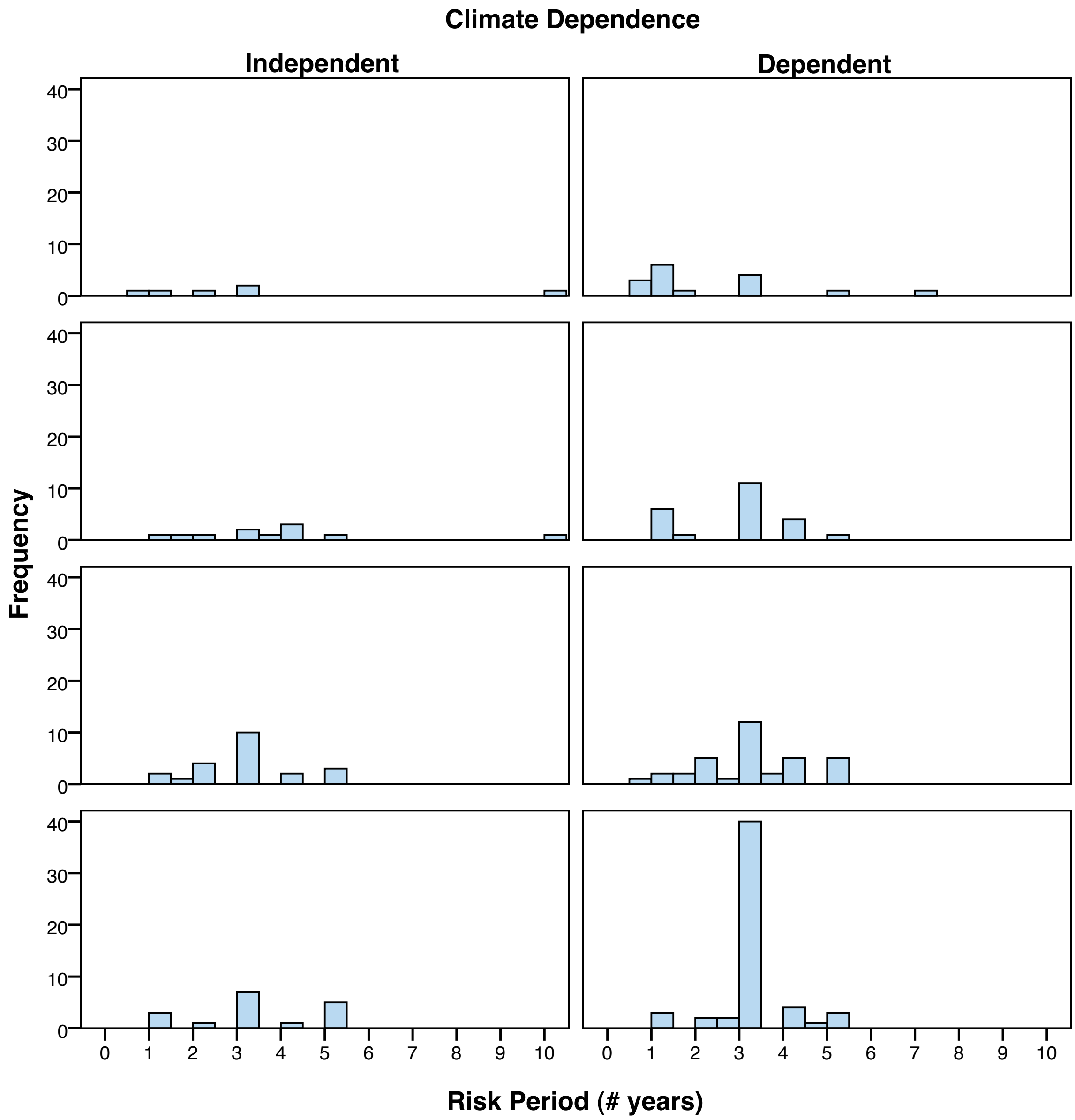

Figure 3: Risk Period Frequency Over Time. The top row contains data for the years 1995 through 1998; the second for 1999-2002; the third for 2003-2006; and the bottom row for 2007-2010.

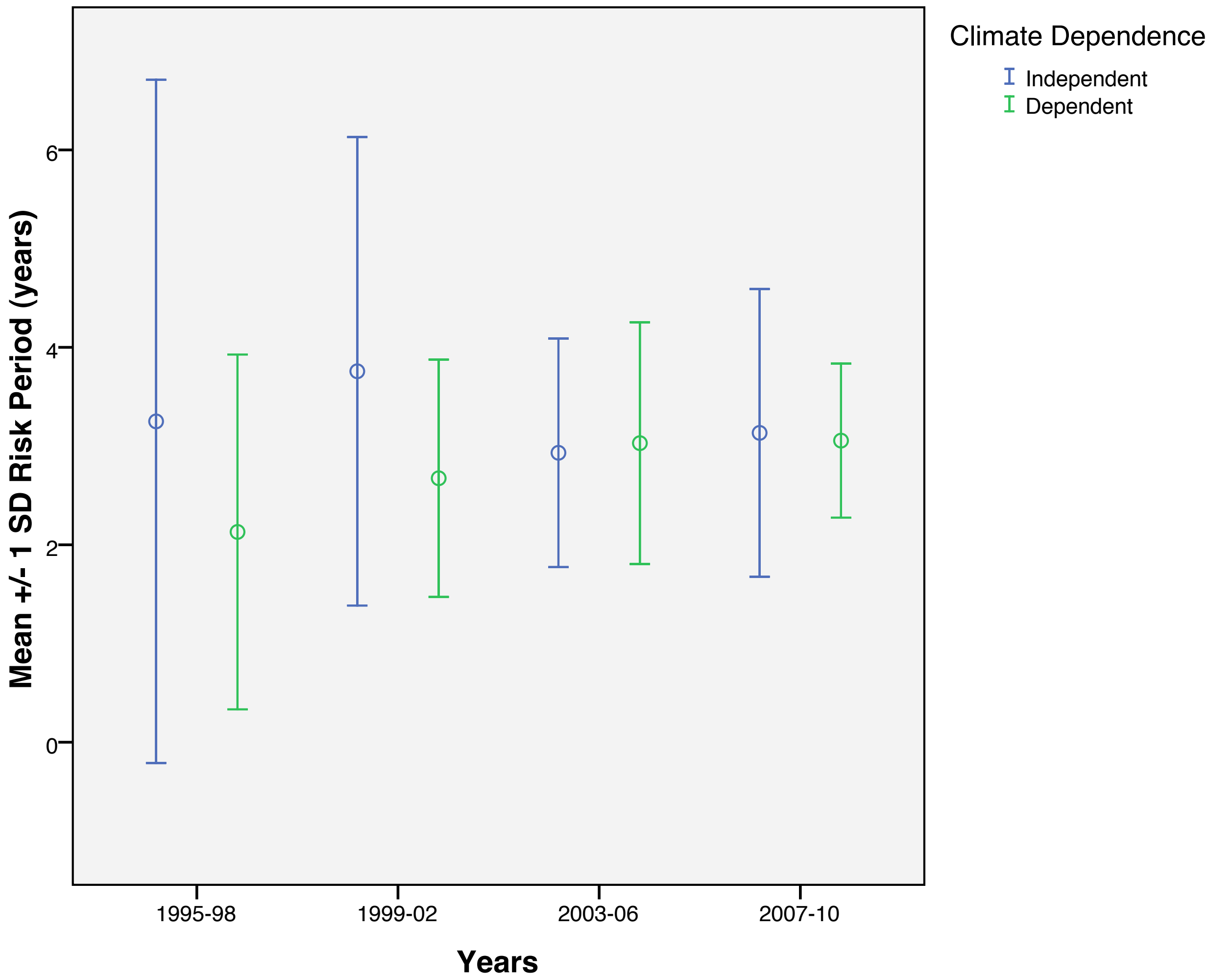

Figure 4: Risk Period Standard Deviation Over Time

regions intersect, the table shows the number of transactions that covered risks in both regions. Where the same regions intersect, it shows the number of deals that cover risks in that region and nowhere else.

Region	USA	Europe	Japan	Other	Total
USA	96*	33	23	15	138
Europe		14*	25	9	53
Japan			18*	7	46
Other				4*	21

USA, Japan, and Europe: 21
* indicates no other region covered

Table 4: Catastrophe Bonds With Overlapping Coverage

Table 4 shows that the catastrophe bond market is dominated by the US, Europe and Japan. Even within these regions, however, the US is by far the biggest player. Figure 5 shows a Venn diagram with the size of the circles representing the total value of all transactions (in 2010 USD) covering risks in each region. The area of the overlapping portions represents the total value of transactions covering risks in multiple regions.

5.2.1 Types of Risks Covered

The most frequently covered risks are windstorms in the US, such as hurricanes on the Gulf and Atlantic Coasts, (96 transactions), earthquakes in California (78), windstorms in Europe (45), earthquakes in Japan (37) and windstorms in Japan (13).

Of the 190 transactions studied, only 42 covered risks that were *not* one of the five above. Of these, six covered the risk of an earthquake in the US, but outside of California (typically in the New Madrid seismic zone in the southern and

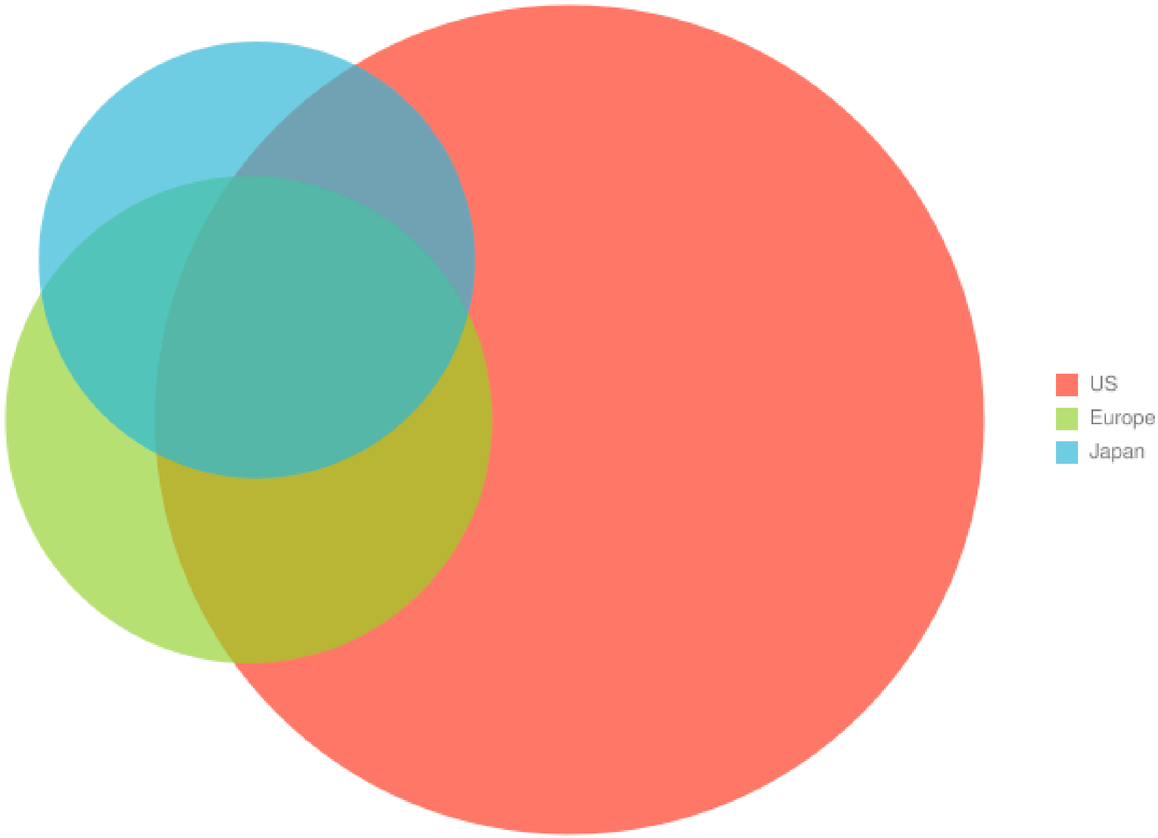

Figure 5: The Relative Sizes of the Three Largest Markets

midwestern US), six covered the risk of a severe storm (such as a thunderstorm or hailstorm) in the US, eight covered the risk of extreme mortality (in a combination of European countries, the US and Japan), and 11 covered earthquakes in various locations.

Only six transactions covered climate dependent risks outside of the US, Japan and Europe; these risks were limited to hurricanes and other natural disasters in the Caribbean[1] and tropical cyclones in Australia.

[1]Unfortunately, the data available for these transactions did not specify where in the Caribbean these risks were located

6 Discussion

The analysis in this paper is an initial attempt to deduce whether or not climate risk is allocated by markets. Because climate risk is not a discrete quality, but is instead continuous, there is no attempt made to quantify the amount of climate risk traded. It is argued that climate risk is a risk that can be separated from and treated in a meaningfully-different manner than weather risk, and attempt to uncover qualitative changes in the treatment of these forms of risk. Furthermore, it is argued that the market's treatment of this risk impacts individuals' ability to make climate-optimal investment decisions.

Most types of insurance transactions are not suitable for the transfer of climate risk, and of those that are, only catastrophe bonds form a meaningful market. My analysis focuses on two parameters: time, the duration of the risk period, and space, the location of the risk being covered. The temporal parameter indicates the extent to which the contract is covering "weather" versus "climate" risk. The spatial parameter is included because climate change will have uneven effects across space; climate risks will therefore be tied to a specific location. For each contract, the temporal parameter exists on a continuum, rather than within a discrete set of values. The extent to which a given risk period will cover climate versus weather risk depends on how quickly changes to the climate are likely to materialize. Because this debate is outside the purview of this paper, all that is said here is that these forms or risk are end-points on a spectrum whose axis is time. Therefore, this study looks only for *movements* along this spectrum rather than attempting to characterize the significance of any individual point.

6.1 Temporal

The most obvious conclusion from the data on risk period durations is that the durations have stayed relatively close to three years throughout the life of the market. Although the significance of this value can be debated, because climate change is expected to evolve over a much longer period, the initial presumption must be that these short durations are enough time to effectively encapsulate and convey climate risk.

While the mean maturity of climate dependent transactions has stayed constant, the structure of the market changed significantly. It seems that the three year maturity has now become the *de-facto* industry standard, at least for climate dependent transactions. That a single duration would emerge as the standard might be expected: catastrophe bonds are deals with high transaction costs. Third parties are needed to establish special purpose companies, perform expensive modeling, structure different tranches, rate the bond, and serve as the placement agent. The work performed in each of these roles is necessarily somewhat different for different contract terms, including different maturities. It is thus not surprising that the market would "converge" to a specific maturity in much the same way that markets often converge to a specific technology in the face of network effects and increasing returns (Arthur, 1994). This suggests that it is possible that there is perhaps very little - or nothing - that is special about the three-year maturity, and that it may have been "chosen" almost by random by increasing returns to adoption.

This is, however, an unfortunate development from a climate-adaptation perspective. It may be the case that this market has, or will soon be, "locked-in" to this maturity. It may be the case that in the future there is both potential demand and supply for contracts with deeper climate risk coverage, but that support for longer maturities will not exist in the market. This inflexibility has, obviously, not been proven, but the data here are preliminary evidence that the option value associated with the capability of trading longer-dated contracts is being or has been lost.

6.2 Spatial

Perhaps more notable then the depth of the market in climate risk is its breadth. As stated above in section 5.2, only *six* catastrophe bond transactions have covered climate dependent risks outside of the US, Europe or Japan, and the only two locations covered by these transactions were Australia and the Caribbean. While there is much discussion of schemes to improve access to weather-related insurance in developing countries, mostly through index-based microinsurance schemes (see Warner et al. 2010, for example), these schemes function to transfer weather risk, and not climate risk, as explained above in section 3.3.1.

To the extent that climate risk is traded at all within the insurance market, the risks traded are located in very few relatively wealthy locations. Vast regions of the world are not served by this market, including most of Asia, all of Africa, all of South America, and almost all of Central America. This is obviously not because large risks do not threaten these regions; recent floods in Pakistan and wildfires in Russia attest to this fact (Masood & Gillani, 2010; Parfitt, 2010).

6.3 Implications

The results of this analysis give a clear indication that climate risk is not traded to any significant extent, at least within the confines of the insurance sector. As stated above, since this paper limited its analysis to this sector of the economy, it is necessarily non-exhaustive. While the depth of this market, where it exists, can be debated, there is no debate as to its breadth: there is no market at all in most of the world.

This is not to say that this will always be the case. The evidence here is that the catastrophe bond market has converged to the three year maturity, so it may be difficult for the market to shift other risk period durations, but this is not to suggest that the same difficulty would apply to extending the reach of this market to other regions. In addition, catastrophe derivatives are promising as an alternative mechanism, but currently the only contracts traded have settlement dates at most one or two years into the future (CME; IFEXb).

For now, what are the implications of this "missing market"? As discussed in section 3.2, climate risk is a cost that in a best-case scenario would be allocated optimally via a market. If this not the case, as this analysis suggests, then attention must be given to other ways of treating the risk. Without any other intervention, individuals and firms will be left to "dispose" of the risk themselves, by relying on subjective judgments for their decisions. Given that the set of responses to climate change can be thought of as substitutes (Tol, 2005; Ingham et al., 2007), it also bears investigation into whether or not other responses can "stand-in" for this market.

The extent to which individuals and firms have the ability to effectively make and incorporate subjective judgments regarding climate risks has not been well explored or tested. Because this analysis suggests that there is not currently an objective (i.e., market-based) mechanism for incorporating climate risk into investment decision-making, any estimate of the expected amount of autonomous anticipatory adaptation to climate change will depend on this ability.

Different responses to climate change - mitigation and adaptation, for example - are policy substitutes, because increasing the amount spent on one class of measures reduces the optimal amount to be spent others. This is also broadly true *within* these categories; increasing the amount of resources expended to reduce emissions in one sector reduces the optimal amount spent in others; increasing the amount of anticipatory adaptation reduces the need for concurrent adaptation, and so on. This analysis, because it calls into question the amount of autonomous anticipatory adaption that should be expected, shifts the burden onto other policy responses to climate change, both within the "adaptation" category and from adaptation to mitigation. Given that there have been very few attempts at disaggregating different forms of adaptation in modeling optimal policy, it is not immediately clear how large of a share autonomous anticipatory adaptation would occupy in an optimal case; initial attempts indicate that it is quite large, however (Bosello et al., 2009). Furthermore, the ultimate implications of this diminished capacity also depend on the "elasticity" of substitution amongst different adaptive or mitigative responses, or the amount of additional resources needed to achieve the same effect with a different policy.

One possibility that bears investigation is substituting "planned" for autonomous adaptation. Governments can influence investment behaviour, either directly through regulation, or indirectly through information provision. It is possible that government action could produce more climate-optimal investment behavior. This seems like a likely "second-best" approach for integrating climate concerns into investment decisions, although it remains to be seen how completely and effective this approach could be.

7 Conclusion

This paper first discussed different forms of adaptation; in particular, this study focuses on uncoordinated action taken in advance of climate change. It is argued that the extent to which this form of adaption will be optimally realized depends on how accurately investors evaluate the likelihoods of changes to the climate. By investigating the extent to which we should expect investment to account for future climate change, this paper attempts to make a contribution to our understanding of how efficiently the economy will adapt to climate change.

Because we will not know how investors actually performed with respect to the climate for some time, the best that can be done today is to make inferences about how well we should expect investors to make climate-optimal investments by investigating the inputs into such decisions. One channel through which this information might be transmitted to investors is through markets in which climate risk is traded.

This paper therefore developed a conceptual framework for understanding how such risk could be traded. This included distinguishing climate from weather risk, and identifying the types of transactions that are capable of transferring this risk. It is concluded that "climate" and "weather" risks can be thought of as end-points on a continuum whose axis is time. As the time under consideration (and the number of weather observations) increases, the underlying distribution (the climate) becomes more visible, and the relevant risk changes from weather risk to climate risk. Furthermore, climate risks are very large; insurance transactions designed to aggregate small subjective risks into an objective portfolio are incapable of doing so with climate risks. Only transactions that are designed to divide large risks into small slices, which in turn can be aggregated into a portfolio of many small slices of risk, are capable of transferring climate risk.

Catastrophe bonds, which are one such transaction, were the object of study. Other "candidate" transactions were not included because their market was too small to be relevant. It is concluded that the market in climate risk as traded in catastrophe bond transactions remained extremely "narrow" and relatively "shallow": climate dependent transactions covered very few regions, and the foresight of the market remained unchanged over the life of the market, hewing to an average of three years. The market did show a significant convergence to the three year maturity, however, with transactions deviating from this value becoming less likely over time. It seems that this value might have become the *de facto* industry standard, and that the market may be locked-in due to high transaction costs and network effects.

This paper raises a number of questions for further research. First, dynamics in both the catastrophe bond market and the catastrophe derivatives market should be monitored. It may be the case either that the catastrophe bond market "breaks out" of the three-year maturity and starts covering longer risk durations; it may also be the case that the catastrophe derivatives market grows and that longer-dated insurance futures become visibly traded, or that climate risk is traded in other sectors of the economy. Second, if it is the case that the market is incapable of providing price signals that convey climate risk, it may be the case that individual investors are capable of making their own judgments, or that governments, either through regulation or by disseminating information, can effectively stand in for this missing market. Finally, autonomous anticipatory adaptation is just one response to climate change, among many. More research should be done into what share this response occupies in optimal climate policy, and how effectively other responses may substitute for this particular form of adaptation.

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Appendix

Table 5: Catastrophe Bond Transactions Since 1995

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Unknown	May-95	1.67	14.4	Dependent	Yes	Yes	Yes	Yes	Yes	Yes	Caribbean and Australian Castrophes
Unknown	Oct-96	3	70	Independent	No	No	No	Yes	No	No	
Hannover Re K2[2]	Nov-96	5	140	Dependent	Yes	Yes	No	Yes	Yes	Yes	Canadian wind and earthquake; Northern European flood; earthquake; landslide; avalanche; Australian wind and earthquake; Aviation XL
Georgetown Re[3]	Dec-96	3	33.6	Dependent	Yes	Yes	No	Yes	Yes	No	Carribean P&C; marine; aviation
Unknown[4]	Jan-97	3	376.4	Dependent	No	Yes	No	No	No	No	

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[2](Hannover Re)
[3]Geo (2009)
[4]Cox & Pedersen (2001)

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Reliance Nationa l	Apr-97	1.33	13.7	Dependent	na	na	na	na	na	na	Specific risks unknown but description indicates they are climate related
Residential Re	Jun-97	1.00	652.9	Dependent	Yes	No	No	No	No	No	
SR Earthquake Fund Ltd	Jul-97	2	187.5	Independent	No	No	No	Yes	No	No	
No Name	Aug-97	3	136.9	Dependent	na	na	na	na	na	na	Specific risks unknown but description indicates they are climate related
Parametric Re	Dec-97	10	136.9	Independent	No	No	No	No	No	Yes	
Trinity Re	Mar-98	0.83	112.7	Dependent	Yes	No	No	No	No	No	
Unknown	Apr-98	3	40.4	Independent	No	No	No	No	No	Yes	
Reliance Nationa l II	May-98	0.75	27	Dependent	na	na	na	na	na	na	Specific risks unknown but description indicates they are climate related
HF Re	Jun-98	0.5	40.4	Independent	No	No	No	Yes	No	No	

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Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
HF Re	Jun-98	0.5	114.6	Dependent	Yes	No	No	No	No	No	
Residential Re 1998[5]	Jun-98	1	606.5	Dependent	Yes	No	No	No	No	No	
Mosaic Re	Jul-98	1	75.5	Dependent	Yes	No	No	Yes	Yes	No	
Pacific Re	Jul-98	7	107.8	Dependent	No	No	Yes	No	No	No	
No name[6]	Aug-98	1	269.6	Independent	Yes	No	No	Yes	Yes	No	Caribbean hurricane risk
Gemini Re	Dec-98	3	202.2	Dependent	No	Yes	No	No	No	No	
Trinity Re II	Dec-98	1	76.3	Dependent	Yes	No	No	No	No	No	
Mosaic Re II	Mar-99	1	60.3	Dependent	Yes	No	No	Yes	Yes	No	
Concentric Re[7]	Apr-99	10	263.7	Dependent	No	No	No	No	No	Yes	
Halyard Re	May-99	3	22.4	Independent	No	Yes	No	No	No	Yes	
Residential Re 1999[8]	Jun-99	1	263.7	Dependent	Yes	No	No	No	No	No	
Juno Re	Jul-99	3	105.5	Dependent	Yes	No	No	No	No	No	
Domestic Ltd	Sep-99	na	131.9	Dependent	No	No	No	No	Yes	No	
Gold Eagle Capital Ltd	Nov-99	1.5	240	Independent	Yes	No	No	Yes	Yes	No	

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[5] Canabarro, Finkemeier, Anderson, & Bendimerad (1998)
[6] Canabarro, Finkemeier, Anderson, & Bendimerad (1998)
[7] Tokyo Disneyland 1999
[8] Froot (2001)

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Kelvin Ltd	Nov-99	3	65.9	Dependent	No	No	No	No	No	No	US weather derivative portfolio. Perturbations in US weather
Namazu Re	Nov-99	5	131.9	Dependent	No	No	No	No	No	Yes	
Atlas Re	Mar-00	3	255.2	Independent	No	Yes	No	Yes	Yes	Yes	
Seismic Re	Mar-00	1.83	191.4	Dependent	No	No	No	Yes	No	No	
Alpha Wind[9]	Jun-00	1	114.8	Independent	Yes	No	No	No	No	No	
Residential Re IV[10]	Jun-00	1	255.2	Dependent	Yes	No	No	No	No	No	
NeHi Inc.	Jul-00	3	63.8	Dependent	Yes	No	No	No	No	No	
Mediterranean Re	Nov-00	5	164.6	Dependent	No	Yes	No	No	No	No	Earthquakes near Monaco; France
Prime Capital I Hurricane Ltd	Jan-01	3	206.7	Dependent	Yes	No	No	No	No	No	
Prime Capital II Calquake and Eurowind Ltd	Jan-01	3	169.4	Dependent	No	Yes	No	Yes	No	No	

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[9]Firm Analyzes Risks 2000
[10]Lane & Beckwith (2001)

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Western Capital Ltd	Feb-01	2	124.1	Dependent	No	No	No	Yes	No	No	
Gold Eagle Capital 2001 Ltd	Mar-01	1	148.9	Independent	Yes	No	No	No	Yes	No	
SR Wind Ltd	May-01	4	144.5	Dependent	Yes	Yes	No	No	No	No	Hurricanes in Puerto Rico
Catastrophe Swap	Jul-01	1	186.2	Dependent	Yes	Yes	Yes	Yes	No	Yes	
Trinom Ltd	Jul-01	3	201	Dependent	Yes	Yes	No	Yes	No	No	
FIFA	Aug-01	Event	62.1	Dependent	No	No	No	No	No	Yes	World Cup Cancellation
Redwood Capital I Ltd	Dec-01	1	204.8	Independent	No	No	No	Yes	No	No	
Atlas Re II Ltd	Jan-02	3	183.2	Independent	No	Yes	No	Yes	No	Yes	
K3	Apr-02	3	280.9	Dependent	Yes	Yes	No	Yes	Yes	Yes	Worldwide aviation business
St Agatha Re Ltd	Apr-02	3	40.3	Dependent	No	No	No	Yes	Yes	No	
Fujiyama Ltd	May-02	3	85.5	Independent	No	No	No	No	No	Yes	
PIONEER 2002 Ltd A	Jun-02	4	134.1	Independent	Yes	No	No	No	No	No	

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Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
PIONEER 2002 Ltd B	Jun-02	4	111	Dependent	No	Yes	No	No	No	No	
PIONEER 2002 Ltd C	Jun-02	4	97.7	Dependent	No	No	No	Yes	No	No	
PIONEER 2002 Ltd D	Jun-02	4	154.4	Independent	No	No	No	No	Yes	No	
PIONEER 2002 Ltd E	Jun-02	4	77.7	Independent	No	No	No	No	No	Yes	
PIONEER 2002 Ltd F	Jun-02	4	44.1	Independent	Yes	Yes	No	Yes	Yes	Yes	
Residential Re VI Ltd	Jun-02	3	152.7	Dependent	Yes	No	No	No	No	No	
Studio Re	Dec-02	3.5	213.7	Dependent	No	No	No	Yes	No	No	
Residential Re 2003[11]	Jun-03	3	191	Independent	Yes	No	No	Yes	Yes	No	
Arbor I/II Ltd	Aug-03	4	145.7	Dependent	Yes	Yes	No	Yes	No	Yes	
Catastrophe Swap	Aug-03	na	119.4	Dependent	Yes	Yes	Yes	No	No	No	
Formosa Re	Aug-03	3	119.4	Dependent	No	No	No	No	No	No	Earthquakes in Taiwan
Oak Capital Ltd	Aug-03	4	28.7	Independent	No	Yes	No	No	No	No	

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[11]Reactions 2006

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Palm Capital Ltd[12]	Aug-03	4	26.3	Dependent	Yes	No	No	No	No	No	
Phoenix Quake Ltd[13]	Aug-03	5	229.8	Dependent	No	No	No	No	No	Yes	
Phoenix Quake Wind Ltd[14]	Aug-03	5	331.3	Independent	No	No	Yes	No	No	Yes	
Sakura Ltd	Aug-03	4	17.9	Dependent	No	No	No	No	No	Yes	
Sequoia Capital Ltd	Aug-03	4	27.5	Independent	No	No	No	Yes	No	No	
Golden Goal Finance Ltd[15]	Sep-03	Event in 2006	521.8	Independent	No	No	No	No	No	No	Anything that would cancel the 2006 World Cup in Germany; including terrorist attack or na tural disaster

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[12] Swiss Re 2003
[13] S&P 2004
[14] S&P 2004
[15] Catastrophe Securitizations 2004

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Vita Capital Ltd[16]	Dec-03	3	477.6	Independent	No	No	No	No	No	No	Extreme mortality in US; UK; Italy; France; Switzerland
Pylon Ltd[17]	Jan-04	5	270.4	Independent	No	Yes	No	No	No	No	
Helix 04 Ltd	May-04	5	116.3	Dependent	Yes	Yes	No	Yes	Yes	Yes	
GI Capital	Jun-04	5	145.4	Dependent	No	No	No	No	No	Yes	
Residential Re 2004	Jun-04	3	264.6	Independent	Yes	No	No	Yes	Yes	No	
Foundation Re[18]	Nov-04	4	287.9	Dependent	Yes	No	No	Yes	Yes	No	
Redwood Capital V/VI	Jan-05	2	337.5	Dependent	No	No	No	Yes	No	No	
Vita Capital II[19]	Apr-05	5	407.2	Independent	No	No	No	No	No	No	Extreme mortality in US; UK; Japan; Germany and Canada

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[16]Catastrophe Securitizations 2004
[17]Reactions 2003
[18]McGhee, Faust, & Clarke (2005)
[19]Swiss Re 2009a

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Cascadia Ltd	Jun-05	3	337.5	Independent	No	No	No	Yes	Yes	No	British Columbia earthquake
Residential Re 2005	Jun-05	3	198	Dependent	na	na	na	na	na	na	Specific risks unavailable; all others in series covered US hurricane risks
Avalon Re	Jul-05	3	455.6	Dependent	No	No	No	No	No	No	Covers liability risk for Oil Casualty; a mutual held by 80 oil companies
Kamp Re	Aug-05	2.5	213.7	Independent	Yes	No	No	No	Yes	No	
Aiolos Ltd[20]	Nov-05	3.5	144.8	Dependent	No	Yes	No	No	No	No	
Atlantic and Western Re	Nov-05	5	618.7	Dependent	Yes	Yes	No	Yes	No	No	
Champlain Ltd	Dec-05	3	84.4	Dependent	No	No	No	Yes	Yes	Yes	
Champlain Ltd	Dec-05	3	16.9	Independent	Yes	No	No	Yes	Yes	No	

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[20] Swiss Re 2009a

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Australis Ltd[21]	Feb-06	3	145.8	Dependent	No	No	No	No	No	No	Australian Earthquake; Australian Tropical Cyclone
Redwood Capital VII/VIII	Feb-06	2	245.2	Dependent	No	No	No	Yes	No	No	
Calabash Re	May-06	3	109	Independent	Yes	No	No	No	No	No	
Cat-Mex Ltd	May-06	3	174.4	Dependent	No	No	No	No	No	No	Mexican earthquake
Residential Re 2006	May-06	3	128	Dependent	na	na	na	na	na	na	Specific risks unavailable; all others in series covered US hurricane risks
Tartan	May-06	3	168.9	Dependent	No	No	No	No	No	No	Extreme mortality
Carillon Ltd	Jun-06	3.5	92.1	Independent	Yes	No	No	No	No	No	
Mystic Re Ltd[22]	Jun-06	3	572.1	Dependent	Yes	No	No	No	No	No	

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[21] Swiss Re 2006a
[22] Mystic Re 2006

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Successor Cal Quake Parametric	Jun-06	2	52.3	Dependent	No	No	No	Yes	No	No	
Successor Euro Wind Class AI/BI/CI	Jun-06	2	247.4	Independent	No	Yes	No	No	No	No	
Successor Euro Wind Class AII/CII	Jun-06	1	6.5	Dependent	No	Yes	No	No	No	No	
Successor Hurricane Industry Class BII/CII	Jun-06	1	49	Dependent	Yes	No	No	No	No	No	
Successor Hurricane Industry Classes B-F I	Jun-06	1.5	124.2	Dependent	Yes	No	No	No	No	No	
Successor Hurricane modelled	Jun-06	1.5	45.8	Dependent	Yes	No	No	No	No	No	
Successor II/III/IV	Jun-06	2	288.8	Dependent	Yes	Yes	No	Yes	No	Yes	
Successor Japan Quake	Jun-06	2	218	Dependent	No	No	No	No	No	Yes	

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Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Successor Japan Quake Class CII	Jun-06	1	3.3	Independent	No	No	No	No	No	Yes	
Vasco Re	Jun-06	3	54.5	Independent	Yes	No	No	No	No	No	
DREWCAT Capital Ltd[23]	Jul-06	0.5	54.5	Dependent	Yes	No	No	No	No	No	
Cascadia II Ltd	Aug-06	3	326.9	Dependent	No	No	No	Yes	Yes	No	Earthquakes in portions of British Columbia, Canada
Eurus Ltd	Aug-06	3	163.5	Independent	No	Yes	No	No	No	No	
Fhu-Jin Ltd	Aug-06	5	218	Dependent	No	No	Yes	No	No	No	
Shackleton Re Ltd Class A	Aug-06	1.5	136.2	Dependent	No	No	No	Yes	No	No	
Shackleton Re Ltd Class B	Aug-06	2	65.4	Independent	Yes	No	No	No	No	No	
Shackleton Re Ltd Class C	Aug-06	2	54.5	Dependent	Yes	No	No	Yes	No	No	
Bay Haven Ltd	Sep-06	3	218.2	Dependent	Yes	Yes	Yes	Yes	Yes	Yes	
Foundation Re II Ltd Class A	Nov-06	4	196.2	Dependent	Yes	No	No	No	No	No	

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[23] DREWCAT 2006

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Foundation Re II Ltd Class G	Nov-06	2	73.6	Dependent	Yes	No	No	Yes	Yes	No	US tornado/hailstorm
Osiris Capital[24]	Nov-06	3	481.7	Dependent	No	No	No	No	No	No	Extreme mortality in France; Japan; US
Atlas Re III[25]	Dec-06	3	172.2	Independent	No	Yes	No	No	No	Yes	
Lakeside Re Ltd[26]	Dec-06	3	207.1	Dependent	No	No	No	Yes	No	No	
Redwood Capital IX Ltd	Dec-06	1	326.9	Independent	No	No	No	Yes	No	No	
Calabash Re II[27]	Jan-07	3	91.1	Independent	Yes	No	No	Yes	Yes	No	
Calabash Re II[28]	Jan-07	3	14.8	Dependent	No	No	No	Yes	Yes	No	
Calabash Re II[29]	Jan-07	3	159	Independent	Yes	No	No	No	No	No	

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[24] Swiss Re 2006b
[25] Best 2006
[26] Zurich 2009
[27] ACE 2009
[28] ACE 2009
[29] ACE 2009

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Vita Capital III[30]	Jan-07	5	349.7	Dependent	No	No	No	No	No	No	Extreme mortality in US; UK; Japan; Germany; Canada
Vita Capital III[31]	Jan-07	4	394.3	Independent	No	No	No	No	No	No	Extreme mortality in US; UK; Japan; Germany; Canada
Ajax Re Ltd	Apr-07	2	106	Independent	No	No	No	Yes	Yes	No	
Blue Wings Ltd	Apr-07	4.75	159	Independent	No	No	No	No	Yes	No	River floods in Great Britain
East Lane Re Ltd	Apr-07	4	265	Dependent	Yes	No	No	No	No	No	
Akibare Ltd[32]	May-07	5	127.2	Dependent	No	No	Yes	No	No	No	
Longpoint Re[33]	May-07	3	529.9	Dependent	Yes	No	No	No	No	No	
Mystic Re II	May-07	4	159	Dependent	Yes	No	No	No	No	No	
Fremantle Ltd	Jun-07	3	254.4	Dependent	Yes	Yes	Yes	Yes	Yes	Yes	

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[30] Swiss Re 2007
[31] Swiss Re 2007
[32] Mitsui Sumitomo Insurance 2007
[33] A.M. Best 2007

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Fusion Ltd	Jun-07	2	148.4	Dependent	No	No	Yes	No	No	No	Mexican earthquake
Merna Reinsurance Ltd[34]	Jun-07	3	1,271.80	Dependent	Yes	No	No	Yes	Yes	No	US and Canada: hurricane; earthquake; tornado; hail; winter storm; brush fire
Nelson Re Ltd	Jun-07	3	79.5	Dependent	Yes	Yes	No	Yes	Yes	No	
Residential Re	Jun-07	3	635.9	Dependent	Yes	No	No	Yes	Yes	No	
Spinnaker Ltd	Jun-07	na	402.9	Dependent	Yes	No	No	No	No	No	
Willow Re Ltd	Jun-07	3	265	Dependent	Yes	No	No	No	No	No	
Midori Re[35]	Oct-07	5	275.6	Dependent	No	No	No	No	No	Yes	
Atlas Re IV	Nov-07	3	249.1	Independent	No	Yes	No	No	No	Yes	
Blue Fin Ltd[36]	Nov-07	5	308.1	Dependent	No	Yes	No	No	No	No	
Globecat Ltd	Dec-07	1	26.5	Dependent	No	No	No	No	No	No	Earthquakes in Guatemala and El Salvador
Globecat Ltd - US Tranches	Dec-07	5	21.2	Independent	No	No	No	Yes	Yes	No	

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[34] Fitch 2007
[35] Mid (2007)
[36] Blu (2007)

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Globecat Ltd - US Tranches	Dec-07	5	42.4	Independent	Yes	No	No	No	No	No	
Green Valley Ltd	Dec-07	3	305.2	Dependent	No	Yes	No	No	No	No	
Newton Re[37]	Dec-07	3	92.7	Dependent	No	No	No	Yes	Yes	No	
Newton Re[38]	Dec-07	3	145.7	Independent	Yes	No	No	No	No	No	
Redwood Capital X[39]	Dec-07	1	528.4	Independent	No	No	No	Yes	No	No	
Nathan Ltd	Feb-08	5	1,531.40	Independent	No	No	No	No	No	No	Extreme mortality in US; Canada; England and Wales; and Germany
Newton Re Ltd	Feb-08	3	153.1	Independent	Yes	Yes	Yes	Yes	Yes	Yes	
Queen Street[40]	Mar-08	3	273.3	Dependent	No	Yes	No	No	No	No	

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[37] Catlin 2008
[38] Catlin 2008
[39] CSX 2007
[40] Munich Re 2008

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
East Lane Re II	Apr-08	3	204.2	Dependent	Yes	No	No	Yes	Yes	Yes	Fire; explosion; lightning; volcanic action; wildfire; mudslides; overflowing of body of water; falling objects in US and Canada
Globe Re	May-08	1	135.8	Dependent	Yes	na	na	na	na	na	
Mangrove re Ltd	May-08	1	214.4	Dependent	Yes	No	No	No	No	No	
Muteki Ltd	May-08	3	306.3	Independent	No	No	No	No	No	Yes	
Residential Re 2008	May-08	3	357.3	Dependent	Yes	No	No	Yes	Yes	No	
Valais Re	May-08	3	106.2	Dependent	Yes	Yes	Yes	Yes	Yes	Yes	
Caelus Re Ltd	Jun-08	3	255.2	Dependent	Yes	No	No	Yes	Yes	No	
Nelson Re Ltd (2008-1)	Jun-08	3	183.8	Dependent	Yes	Yes	No	Yes	Yes	No	
Vega Capital Ltd	Jun-08	3	153.1	Dependent	Yes	Yes	Yes	Yes	No	Yes	
Willow Re Ltd	Jun-08	3	255.2	Dependent	Yes	No	No	No	No	No	

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Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Blue Coast Ltd	Jul-08	2.5	122.5	Dependent	Yes	No	No	No	No	No	
Topiary Capital Ltd	Aug-08	3	204.2	Dependent	Yes	Yes	No	Yes	Yes	Yes	
Atlas Reinsurance V Ltd	Feb-09	3	204.8	Dependent	Yes	No	No	Yes	Yes	No	
East Lane Re II	Feb-09	3	153.6	Dependent	Yes	No	No	No	No	No	
Mystic Re II	Mar-09	3	230.5	Dependent	Yes	No	No	No	Yes	No	
Blue Fin Ltd	Apr-09	3	184.4	Dependent	Yes	No	No	Yes	Yes	No	
Ibis Re Ltd	Apr-09	3	153.6	Dependent	Yes	No	No	No	No	No	
Successor II Ltd[41]	Apr-09	1	61.5	Dependent	Yes	No	No	Yes	No	No	
Residential Re 2009 Ltd[42]	May-09	3	256.1	Dependent	Yes	No	No	Yes	Yes	No	Severe thunderstorms in US; winter storms in US; wildfires in California only
Calabash Re III[43]	Jun-09	3	14.3	Independent	No	No	No	Yes	Yes	No	

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[41] Munich Re 2010
[42] Martucci & Margalit (2009)
[43] Martucci & Macdonald (2009)

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Calabash Re III - Class A[44]	Jun-09	3	88.1	Dependent	Yes	No	No	Yes	Yes	No	
Ianus Capital	Jun-09	3	68.6	Dependent	No	Yes	No	No	No	No	Earthquake in Turkey
Eurus II	Jul-09	2.5	210.5	Dependent	No	Yes	No	No	No	No	
Parkton Ltd	Jul-09	2	204.8	Dependent	Yes	No	No	No	No	No	
MultiCat Mexico 2009 Ltd	Oct-09	3	297	Dependent	No	No	No	No	No	No	Earthquakes in Mexico
Montana Re Ltd	Nov-09	3	179.2	Dependent	Yes	No	No	Yes	Yes	No	
Successor X Ltd	Nov-09	1	153.6	Dependent	Yes	No	No	Yes	No	No	
Vita Capital IV Ltd[45]	Nov-09	5	76.8	Independent	No	No	No	No	No	No	Extreme mortality in US or UK
Atlas VI Capital Ltd	Dec-09	3.33	76.8	Dependent	No	Yes	No	No	No	Yes	
Lakeside Re II Ltd	Dec-09	3	225	Independent	No	No	No	Yes	No	No	
Longpoint Re II Ltd	Dec-09	3	512.1	Dependent	Yes	No	No	No	No	No	
Redwood Capital XI Ltd	Dec-09	1	153.6	Independent	No	No	No	Yes	No	No	

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[44] Martucci & Macdonald (2009)
[45] Swiss Re 2009b

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Foundation Re III Ltd	Jan-10	4	180	Dependent	Yes	No	No	No	No	No	
Merna Re II Ltd[46]	Mar-10	3	350	Independent	No	No	No	Yes	Yes	No	
Successor X Ltd (Series 2010-1)	Mar-10	3	120	Dependent	Yes	Yes	No	No	No	No	
Blue Fin Ltd	May-10	3	150	Dependent	Yes	No	No	Yes	Yes	No	
Caelus Re II Ltd	May-10	3	185	Dependent	Yes	No	No	Yes	Yes	No	
EOS Wind Ltd	May-10	4	80	Dependent	Yes	Yes	No	No	No	No	
Ibis Re II Ltd (Series 2010-1)[47]	May-10	3	150	Dependent	Yes	No	No	No	No	No	
Johnston Re Ltd	May-10	3	305	Dependent	Yes	No	No	No	No	No	
Lodestone Re Ltd[48]	May-10	3	425	Dependent	Yes	No	No	Yes	Yes	No	

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[46]Martucci & Newman (2010)
[47]Davidson & Newman (2010)
[48]Chartis 2010

Name of Transaction	Date	Risk Period (years)	Inflation-Adjusted Value (mm 2010 USD)	Climate Dependence	US Windstorm	Euro Windstorm	Japan Windstorm	CA Earthquake	US Earthquake	Japan Earthquake	Other Risks
Residential Re	Jun-10	3	400	Dependent	Yes	No	No	Yes	Yes	No	Severe thunderstorm and winter storm risks in 48 contiguous states and in DC; Wildfire coverage in CA
Shore Re Ltd.	Jul-10	3	100	Dependent	Yes	No	No	No	No	No	

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